Res. Bull. Pl. Prot. Japan No. 40: 25～32 (2004)

Irradiation Effects on Insect Pests of Cut Flowers

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Abstract: The authors treated the two spotted spider mite, *Tetranychus urticae* Koch, which mite was the most tolerant to irradiation among several tested species of typical cut flower pests, such as the American serpentine leafminer, the Comstock mealybug, the melon thrips, the onion thrips, the green peach aphid, and the common cutworm, by gamma ray irradiation with a dose of 400 Gy, at a commercial irradiation facility, under actual plant quarantine conditions with Alstroemeria, stock and carnation as typical imported cut flowers, which were relatively tolerant to irradiation. As a result of the irradiation, about 17,000 eggs and 1,400 female adults were completely sterilized. Injury to the flowers was controlled to some degrees, but it must to be noted that some injury was observed depending on flower varieties.
Key words: irradiation, gamma rays, sterilization, *Tetranycus urticae*, cut flower, quarantine treatment

Introduction

The Interim Commission on Phytosanitary Measures (ICPM) of the International Plant Protection Convention (IPPC) had discussion on and adopted a standard: "Guidelines for the use of irradiation as a phytosanitary measure", in April 2003. Without doubt, the technique of sterilization by irradiation of plant pests will be an important quarantine measure after the fading out of methyl bromide. Researchers of the Plant Protection Station of Japan have made efforts through the years toward establishing irradiation on plants, especially cut flowers, as a quarantine treatment, and they have already accumulated knowledge on the susceptibility of typical imported cut flowers and their insect pests to irradiation. Based on the data of those reports, the authors attempted a large-scale test to verify, finally, the irradiation effect on insect pests of cut flowers under the conditions simulating the commercial and actual quarantine situation of imported cut flowers.

Materials and Methods

The two-spotted spider mite, *Tetranychus urticae* Koch, which was the most tolerant to irradiation among tested insect pests: the American serpentine leafminer, *Liriomyza trifolii* (Burgess), the Comstock mealybug, *Pseudococcus comstocki* (Kuwana), the melon thrips, *Thrips palmi* Karny, the onion thrips, *Thrips tabaci* Lindeman, the green peach aphid, *Myzus persicae* (Sulzer) and the common cutworm, *Spodoptera litura* (Fabricius) (Dohino *et al*., 1993, 1994a, 1994b, 1995, 1996a, 1996b, 1997; Kumagai *et al*., 1995), with Alstroemeria, *Alstroemeria* sp. (produced in Yamagata Pref.), stock, *Matthiola incana* (produced in Yamagata Pref.) and carnation, *Dianthus caryophyllus* (produced in Aichi and Chiba Pref.) , which were relatively tolerant to irradiation among 24 kinds of typical imported cut flowers (Tanabe *et al*., 1992, 1993, 1995), was irradiated by gamma rays.

Fig. 1 The two-spotted spider mite on kidney bean leaves (leaf-disc) and the dosimeter.

Fig. 2 Setting of dosimeters (put between the eggs and the female adults leaf-discs).

Fig. 3 Setting leaf-discs and dosimeters in the carton box of cut flowers.

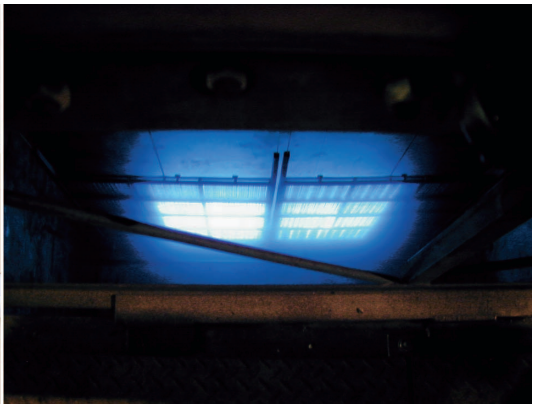

Fig. 4 The radiation source (^{60}Co) in the water (Cherenkov light).

Fig. 5 Setting the target carton boxes in the irradiation room (before the first irradiation).

Fig. 6 Re-setting the target carton boxes in the irradiation room (before the second irradiation).

Table 1. Specification of the irradiated carton boxes of cut flowers and setting positions of dosimeters (Nov. 14, 2002).

Carton box No. 1

Weight	19.0 kg
Size & Volume	26×36×100 cm=93,600 cm^3
Density	0.20 g/cm^3
Cut flower	Alstroemeria

Setting positions of the mites and dosimeters

7	8	9	top
			↑
4	5	4	
			↓
1	2	3	bottom

Carton box No. 2

Weight	18.3 kg
Size & Volume	26×36×100 cm=93,600 cm^3
Density	0.20 g/cm^3
Cut flower	stock

17	18	19	top
			↑
14	15	16	
			↓
11	12	13	bottom

Carton box No. 3

Weight	21.0 kg
Size & Volume	30×30×120 cm=108,000 cm^3
Density	0.19 g/cm^3
Cut flower	Mixture of Alstroemeria, stock and carnation equal in each volume

27	28	29	top
			↑
24	25	26	
			↓
21	22	23	bottom

Carton box of the conrtol

Weight	14.0 kg
Size & Volume	20×35×100 cm=70,000 cm^3
Density	0.20 g/cm^3
Cut flower	Mixture of Alstroemeria, stock and carnation equal in each volume

Three- to 5-day-old eggs and female adults of the two-spotted spider mite were inoculated onto kidney bean leaves on agar medium, to which methylene blue was added, as a disinfectant (Fig. 1). Nine leaf-discs of the mites, with dosimeters, were located in each of three commercial carton boxes (size, about 30×30×100 cm; weight, about 20 kg; density, 0.19–0.20 g/cm^3; Table 1 in detail) packed with Alstroemeria, stock and/or carnation (Figs. 2 and 3).

Three boxes of cut flowers were stacked up about 3 meters' distance from the radiation source in the irradiation room, so that 400 Gy, as an absorbed dose, could be received at the position of these boxes, and they were irradiated by gamma rays from the irradiation equipment (Type JS10000HD, manufactured by MDS Nordion Company,

Table 2. The result of dosimetry in the irradiation on cut flowers (Nov. 14, 2002).

Conditions of dosimetry:
Total exposure time: 18 min. 34 s.
Dosimetry:
1) Dosimeter: Harwell Gammachrome YR
2) Absorption analysis
(1) Instrument: spectrophotometer
(2) Manufacturer: Hitachi, Ltd.
(3) Model: U-2010

Carton No.	Measurement points	Dose (Gy)	Max.	Min.	Average±SD
1	1	370	420	370	383±19
	2	370			
	3	370			
	4	370			
	5	390			
	6	370			
	7	380			
	8	410			
	9	420			
2	11	390	420	360	397±18
	12	360			
	13	380			
	14	400			
	15	400			
	16	410			
	17	400			
	18	410			
	19	420			
3	21	360	420	360	396±19
	22	390			
	23	400			
	24	410			
	25	370			
	26	410			
	27	400			
	28	420			
	29	400			

Table 3. Sterilization effect of gamma irradiation (400 Gy) on the 3- to 5-day old eggs and the female adults of the two-spotted spider mite.

Carton No.	Eggs			Female adults		
	Number of irradiated eggs	Number of emerged adults	Number of laid eggs	Number of irradiated female adults	Number of laid eggs	Number of hatched eggs
1	5,978	144	0	467	2,324	0
2	5,360	272	0	471	1,963	0
3	5,649	475	0	484	1,841	0
Control	2,162	480	6,193	161	837	672

Note: All the figures are total numbers of mites at 9 setting positions in each carton box.

Canada; the radiation source, ^{60}Co; the source storage capacity, 11.1×10^{16} Bq ; Fig. 4) at the Tokai Center of Japan Irradiation Service Inc. (Address : Tokai-mura, Naka-gun, Ibaraki prefecture).

One side of each box was irradiated for 9 minutes and 17 seconds and the opposite side of each box was similarly irradiated after the position of each box in the stack was changed up or down to gain uniform distribution of the absorbed dose (Figs. 5 and 6). The total irradiation time at the end was 18 minutes and 34 seconds (Table 2) .

The absorbed dose (Gy) was measured by a dosimeter of radiation-sensitive polymethyl methacrylate (PMMA) (Gammachrome YR manufactured by the Harwell Company, dose range, 0.1–3 kGy) and the absorbance of the dosimeter was analyzed by a spectrophotometer (Model U-2010, manufactured by Hitachi, Ltd.) .

The eggs were moved to kidney bean seedlings, and the female adults were moved to kidney bean leaves on new agar medium after the irradiation, and they were kept at 28℃.

It was checked as to if eggs could be laid by newly emerged female adults from the irradiated eggs on the kidney bean seedlings at 25 days after the irradiation, and if the eggs that were laid by the irradiated female adults could hatch at 12 days after the irradiation. The injury to the cut flowers after the irradiation was also observed.

Results and Discussion

About 17,000 irradiated 3- to 5-day-old eggs could not produce the adults that would lay eggs and about 1,400 irradiated female adults could not lay eggs that would hatch. They were considered to be completely sterilized by about 400 Gy irradiation (Table 3).

Because the humidity could not be controlled well during the rearing of the mites after the irradiation, the emergence rate of adults from the untreated eggs of the control was lower. Both the irradiated and untreated eggs, however, were kept under the same conditions. Consequently, the adults from the untreated eggs could lay eggs normally, while the adults from the irradiated eggs could not.

The wilt of irradiated stock differed with petal color. The injury of the irradiated stock of pink petals was more severe compared with the control of purple petals at 6 days after the irradiation. The irradiated Alstroemeria was wilted worse than the control at 10 days after the irradiation. There was not much difference between the irradiated and the

Fig. 7 Injuries of irradiated stock (6 days after the irradiation). Control (left), Irradiated (right)

Fig. 8 Injuries of irradiated carnation (6 days after the irradiation). Control (left), Irradiated (right)

Fig. 9 Injuries of irradiated Alstroemeria (6 days after the irradiation). Control (left), Irradiated (right)

control of carnation (Figs. 7, 8 and 9). Carnation had been considered one of the most tolerant flowers. It is noted that some injury was observed depending on the flower varieties.

Our experiment results have proved that generally interecepted pest insects at the import inspection, in the greatest density (circa 0.2 g /cm^3) of the general form of packing of imported cut flowers, can be sterilized by gamma (X-ray) irradiation of 400 Gy as an absorbed dose.

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和 文 摘 要

切花の害虫に対する放射線照射の殺虫効果

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切花に寄生する代表的な害虫であるナミハダニ、マメハモグリバエ、クワコナカイガラムシ、ミナミキイロアザミウマ、ネギアザミウマ、ハスモンヨトウ及びモモアカアブラムシの7種のうち、最も放射線耐性が高かったナミハダニの3〜5日齢卵及び雌成虫を代表的な輸入切花のうち、比較的放射線耐性が高かったアルストロメリア、ストック及びカーネーションとともに、商業放射線処理施設において実際の検疫処理を想定し、ガンマ線により吸収線量約400 Gyを照射した。照射後、処理区及び対照区のハダニを28℃で飼育した結果、ナミハダニの3〜5日齢卵約17,000卵及び雌成虫約1,400頭が完全に不妊化された。切花の放射線障害はある程度抑制されたが、切花の品種によっては顕著な障害が発生するので注意を要する。